Method and Device in a Paper or Board Machine

The present invention concerns a method according to the introduction to claim 1.

The present invention also concerns a device according to the introduction to claim 9.

The method and the device according to the invention are particularly suitable for determining the quantity and the severity of defects in the form of shrinkage creases or other types of crease in the web.

During the manufacture of a web of paper or board in a paper machine or a board machine, and in particular during the production of board from chemo-thermo mechanical pulp(CTMP), it is not unusual that shrinkage creases, which extend along the longitudinal direction of the web, form. The shrinkage creases constitute an undesirable defect of the web that should be reduced as much as is possible by changing the settings of the board machine.

One method that is used to assess the appearance of the web and the occurrence of shrinkage creases is to allow an operator to inspect the web visually, for example during exchange of machine roll, and to estimate the extent of the shrinkage creases. The operator can, for example, estimate the extent on a scale from one to three. There are, however, certain problems associated with such a procedure. Firstly, the procedure is subjective, i.e. there is a risk that different operators will estimate the extent of the same shrinkage creases differently. Secondly, the area of inspection is limited to that part of the web that is visible at the machine roll, i.e. the part of the web that forms the covering surface of the machine roll. Thirdly, it is only possible to discover relatively major changes in a visual inspection. In other words, the resolution of a visual inspection is relatively low.

One way of objectively measuring the surface structure of a web of paper is described in the patent SE 516999. According to the method described, two images of the web are taken in the transverse direction of the web at a pre-determined position. The web is illuminated for the two images by light obliquely incident from two different directions, i.e. the web is illuminated with light that is incident from a first direction during the taking of the first image, and it is illuminated with light incident from a second direction during the taking of the second image. The images are subsequently Fourier-transformed and the spectra obtained are combined to give an approximation of the correct spectrum of the web. It has, however, become apparent that this method of measuring the surface structure of the web is less suitable when shrinkage creases are present. In particular, the step of taking two images with illumination from two different directions is inconveniently complex.

The aim of the present invention is to achieve a method and a device that are particularly suitable for determining in real time the quantity and the severity of shrinkage creases.

The method according to the invention is characterised by the characterising part of claim 1.

The device according to the invention is characterised by the characterising part of claim 9.

The invention will be described in more detail with reference to the figures.

Figure 1 shows schematically and in principle a device according to one preferred embodiment of the invention.

Figure 2 shows a flow chart that illustrates one preferred sequence of steps in order to determine the quantity and the severity of shrinkage creases according to the invention.

Figure 3 shows an image of a surface section of a web of board that demonstrates shrinkage creases.

Figure 4 shows the image according to Figure 3 following an image processing step according to the invention.

Figure 1 shows a device for determining in real-time the quantity and the severity of shrinkage creases that form in a web 1 of board when the web 1 is manufactured in a board machine (not shown in the figure). The device comprises an imaging system, which comprises a camera 2 in the form of a digital CCD camera of the type known as "progressive scan". The camera 2 is arranged above the web 1 and is directed towards a pre-determined area 3 of the web 1, in which area 3 it is desired to analyse the surface structure of the web 1. In the present case, the area 3 is located at one edge section of the web 1. The imaging angle of the camera 2 and the distance between the camera 2 and the web 1 are chosen such that it is possible for the camera 2 to image in the said area 3 a surface section 4 of a pre-determined size of the web 1 when the web 1 passes in front of the camera 2. The device further comprises an illumination system, which comprises a lamp 5 arranged at a pre-determined position above the web in order to illuminate the area 3 with obliquely incident light. The position of the lamp 5 in the present case is at the same height as the camera 2 in the longitudinal direction of the web 1, and the axis of illumination of the lamp 5 forms an angle with the web 1 that lies in the interval 1-15°. The lamp 5 can, however, be placed at another position that provides illumination of the area 3 with obliquely incident light. It is preferable that the lamp 5 comprises a xenon incandescent lamp that provides the required light intensity in a suitable wavelength interval. Other light sources can, however, be used. The device also comprises an image processing system, which comprises a computer 6.

A preferred sequence of steps of determining the quantity and the severity of shrinkage creases using the device described above will be described below with reference to Figures 2-4.

The initial step is an image capture step 7 in which the camera 2 is caused to capture a pre-determined number of images of the web 1 in the light from the lamp 5 as the web 1 passes in front of the camera 2. The images thus form an image sequence that represents a series of surface sections 4, 4', 4", ... along a band 8 in the web 1. A suitable sequence of images may, for example, consist of 50 images taken during a duration of 2 seconds. Figure 3 shows an illuminated surface section from such a sequence, which surface section extends vertically in the figure approximately 0.200 metre along the longitudinal direction of the web and horizontally in the figure approximately 0.267 meter in the transverse direction of the web 1. The camera 2 has in the present case imaged surface sections such as a digital image with a height of 580 pixel lines and a width of 770 pixel columns. Shrinkage creases appear in Figure 3 as dark bands that have an extent in the longitudinal direction of the surface section, i.e. vertically in Figure 3.

The images are transferred to the computer 6 after the image capture step 7, whereby an evaluation step 9 commences. The evaluation step 9 comprises a preparative image processing step 10 and a subsequent image analysis step 11.

The computer 6 carries out a sequence of image operations on each of the images during the image processing step 10. The aim of this step is to reduce contributions from disturbing sources of error, such as, for example, irregular and varying illumination, and to prepare the images for the subsequent image analysis step 11. A first image operation 12 comprises the division of each pixel value in each image with the mean pixel value of the image, after which each pixel value is multiplied by a pre-determined factor, for example 100. A second image operation 13 comprises the cropping of the edges of the image such that the image obtains pre-determined dimensions. The rectangle in Figure 3 indicates such a cropping operation, in which the cropped image has a height of 470 pixel rows and a width of 512 pixel columns. A third image operation 14 comprises the division of the image into groups along the

longitudinal direction of the web 1 with a pre-determined number of consecutive pixel rows in each group, after which new pixel rows are formed through the calculation of the mean value of the pixel values in each pixel column in each group and the assignment of this mean value to the pixels in the new pixel row. A fourth image operation 15 comprises the high-pass filtration of the image in the transverse direction. It is preferable that the high-pass signal is calculated through the subtraction from the original image of a low-pass signal obtained, for example, by causing an FIR Blackman filter to operate on the image. Figure 4 shows the image according to Figure 3 after the image operations specified above, where there are formed 47 groups with 10 pixel rows in each group during the third image operation, after which 47 new pixel rows are formed through the calculation of the mean value of the pixel values in each pixel column in each group and its assignment to the pixels in the new pixel row. Figure 4 makes it apparent that the visible uneven illumination seen in Figure 3 has been reduced through the image operations. Thus, a series of images is obtained from the image processing step 10, which in the present case has a height of 47 pixel rows and a width of 512 pixel columns, in which contributions from disturbing sources of error have been reduced.

The image analysis step 11 commences after the image processing step 10. The image analysis step 11 comprises a first analysis operation 16, in which the variance of the pixel values in each pixel row in each image is calculated within a pre-determined spatial wavelength band. This analysis operation 16 preferably takes place through the Fourier transformation of each pixel row with the aid of an FFT algorithm, after which the variance within the pre-determined band of wavelengths is calculated. Thus, this Fourier transform is one-dimensional. It has become apparent by comparing the visual ranking results using various wavelength bands that a wavelength band comprising the wavelengths 0.7-4 mm correlates well with the irregularities that shrinkage creases cause in board. Other wavelength bands may be relevant for paper. For example, a wavelength band comprising 3-15 mm has proved to be suitable for irregularities

that folds in fine paper cause. The image analysis step 11 further comprises a second analysis operation 17, in which the mean values of the variance of all pixel rows for all images in the series are calculated and displayed on a monitor or stored for future evaluation. This mean value of the variance constitutes a measure of the quantity and the severity of shrinkage creases in the web 1, and an operator can rapidly and easily see trends in shrinkage creasing by comparing the mean value of the variance with results from previously evaluated image sequences, and take suitable measures.

Shrinkage creases can occur over the complete width of the web, but they occur principally at the edge sections of the web. It is therefore preferred that a device according to the invention is directed towards one edge section of the web, as is shown in Figure 1. It will, however, be realised that the arrangement can comprise several imaging and illumination systems that are directed towards different parts of the web. For example, one imaging system and the associated illumination system can be directed towards the second edge section of the web, and an imaging system and its associated illumination system can be directed towards the central section of the web. It is thus possible, by using an arrangement comprising several pairs of imaging systems and illumination systems, to determine in real-time the quantity and the severity of shrinkage creases across the complete width of the web. Alternatively, one pair of an imaging system and an illumination system can be arranged such that it is possible to traverse across the web, and in this way the same imaging system can be used to image different parts of the web or the complete web. The imaging systems and the illumination systems can be arranged above the web, below the web, or both above and below the web.

One preferred sequence of steps for determining the quantity and the severity of shrinkage creases in a web has been described above. It will, however, be realised that the imaging and analysis operations described can be varied within the framework of the invention. Certain operations can be omitted or can be modified and other operations can be added without

the deviating from the principle of the invention. It will also be realised that those parts that are included in a device according to the invention can be varied without deviating from the principle of the invention. For example, a linear recording CCD camera can be used instead of the said camera of "progressive scan" type. In such a case, the said images would be constituted by several lines, which form a sequence that images a surface section along a band in the web.